

TOP SECRET - COMM-F60

WHAT IS CLAIMED IS:

- 1        1. A method of color-calibrating an incremental printer;  
2        said method comprising the steps of, for each of plural  
3        colorants respectively:
  - 4                defining at least one standard maximum tone;
  - 5                establishing an absolute perceptual parameter of the  
6                at least one defined maximum tone;
  - 7                in substantially each printer or printer driver of a  
8                product line, storing a numerical representation of the  
9                established absolute parameter for later use in color-  
10          correction calculations for the printer.
- 1        2. The method of claim 1, wherein:  
2                the storing step is performed before distribution of  
3                the respective printer from a manufacturer of the printer.
- 1        3. The method of claim 2, wherein:  
2                the storing step is performed again for a revised,  
3                second defined standard maximum tone after distribution.
- 1        4. The method of claim 1, wherein:  
2                the defining, establishing and storing steps are per-  
3                formed for at least one nonchromatic colorant and at least  
4                one chromatic colorant in the printer.

DETAILED DESCRIPTION

- 1       5. The method of claim 1, wherein:
  - 2           for at least one chromatic colorant the defining, es-
  - 3           tablishing and storing steps are performed for plural com-
  - 4           binations of printmode and printing medium used in the
  - 5           printer.
  
- 1       6. The method of claim 1, wherein:
  - 2           the defining and establishing steps comprise measur-
  - 3           ing the absolute perceptual parameter for a representative
  - 4           printer in the product line.
  
- 1       7. The method of claim 1, wherein:
  - 2           the defining and establishing steps comprise measur-
  - 3           ing the absolute perceptual parameter for each of repre-
  - 4           sentative printers in the product line, and selecting from
  - 5           among the measurements.
  
- 1       8. The method of claim 1, wherein:
  - 2           the defining and establishing steps comprise measur-
  - 3           ing the absolute perceptual parameter for each of repre-
  - 4           sentative printers in the product line, and combining the
  - 5           measurements.
  
- 1       9. The method of claim 1, further comprising the step  
2       of:
  - 3           in an end-user facility, automatically applying the
  - 4           stored numerical representation in calculations for color
  - 5           correction in the printer.

1       10. The method of claim 10, wherein, for each chromatic  
2       colorant respectively:

3                 the applying step comprises contracting or expanding  
4       the printer dynamic range to force a maximum tone printed  
5       by the printer to match the defined standard tone.

1       11. The method of claim 10, wherein the defining and  
2       establishing steps comprise:

3                 determining the absolute perceptual parameter for  
4       printers that represent extremes of performance of the  
5       product line; and

6                 selecting the numerical representation and selecting  
7       printer operating conditions in view of the determined pa-  
8       rameter for said extremes of performance, to ensure that  
9       in each printer of the product line the applying step will  
10      be able to force the maximum tone to reach the standard  
11      value.

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1       12. The method of claim 9:  
2                 further comprising the steps of, in the end-user  
3         facility but before the applying step:  
4  
5                 using the printer to print a specimen of the  
6         maximum tone, and  
7  
8                 measuring the absolute perceptual parameter for  
9         the specimen;  
10  
11         the applying step further comprises employing the  
12         measured parameter for the specimen, as an instance of the  
13         maximum tone printed in the absence of the contracting or  
14         expanding; and  
15         the contracting or expanding comprises forcing the  
16         measured absolute perceptual parameter for later-printed  
17         instances of the maximum tone to match the established ab-  
18         solute perceptual parameter for the defined standard tone.

1       13. The method of claim 10, wherein:  
2                 the applying step further comprises linearizing later  
3         printing of the respective colorant, using the forced  
4         match as one endpoint of the linearizing.

1       14. The method of claim 10, wherein the contracting or  
2         expanding comprises:  
3                 cutting off maximum tonal density early for marking  
4         arrays that are marking too boldly; and  
5                 extending maximum tonal density to cut off late for  
6         marking arrays that are marking too lightly.

1       15. The method of claim 9, wherein:  
2                 the applying step comprises introducing the correc-  
3                 tion upstream of printmasking.

1       16. The method of claim 1, wherein:  
2                 the defining, establishing and storing steps operate  
3                 with respect to substantially exclusively a single tone  
4                 for each colorant, as distinguished from recording an en-  
5                 tire colorimetric calibration throughout a tonal range.

1       17. A method of color-calibrating an incremental printer  
2                 in an end-user facility; said method comprising the steps  
3                 of, for each of plural colorants in the printer:  
4                 retrieving from the printer or a printer driver a  
5                 stored numerical representation of an absolute perceptual  
6                 parameter for a standard maximum tone; and  
7                 applying the retrieved numerical representation in  
8                 color-correction calculations for the printer.

1       18. The method of claim 17, wherein, for each chromatic  
2                 colorant respectively:  
3                 the applying step comprises contracting or expanding  
4                 the printer dynamic range to force a maximum tone printed  
5                 by the printer to match the defined standard tone.

1       19. The method of claim 18:

2                 further comprising the steps of, before the applying  
3       step:

4

5                 using the printer to print a specimen of the  
6                 maximum tone, and

7

8                 measuring the absolute perceptual parameter for  
9                 the specimen;

10

11                 the applying step further comprises employing the  
12                 measured parameter for the specimen as an instance of the  
13                 maximum tone printed in the absence of the contracting or  
14                 expanding; and

15                 the contracting or expanding comprises forcing the  
16                 measured absolute perceptual parameter for later-printed  
17                 instances of the maximum tone to match the established ab-  
18                 solute perceptual parameter for the defined standard tone.

1       20. The method of claim 18, wherein:

2                 the applying step further comprises linearizing later  
3                 printing of the respective colorant, using the forced  
4                 match as one endpoint of the linearizing.

1       21. The method of claim 18, wherein the contracting or  
2                 expanding comprises:

3                 cutting off maximum tonal density early for marking  
4                 arrays that are marking too boldly; and

5                 extending maximum tonal density to cut off late for  
6                 marking arrays that are marking too lightly.

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1       22. The method of claim 17, wherein:  
2                 the applying step comprises introducing the correc-  
3                 tion upstream of printmasking.

1       23. The method of claim 17, further comprising the step  
2         of, before the retrieving step:  
3                 downloading from a network an updated value of the  
4         numerical representation.

1       24. The method of claim 17, wherein:  
2                 the applying step is performed in the printer by in-  
3                 tegrated circuits operating programs.

1       25. The method of claim 24, wherein:  
2                 the applying step sets the minimum luminosity that  
3         the printer can image, to match the stored numerical  
4         representation.

1       26. The method of claim 17, still for each colorant:  
2                 further comprising the step of printing a tonal ramp;  
3         and  
4                 wherein the measuring step comprises using a calibra-  
5         ted line sensor to measure the printed tonal ramp.

1       27. The method of claim 26, wherein said line-sensor  
2       using comprises:

3                 assembling a set of sensor readings for each tone in  
4       the ramp;

5                 normalizing the readings with respect to the tonal  
6       range between reflection from unprinted printing medium  
7       and the maximum tone; and

8                 based upon nonlinearity in the normalized, adjusted  
9       and referred readings, determining a correction function  
10      to establish linearity in the readings.

TOP SECRET - DEFENSE

1       28. A method of providing substantially absolute color  
2       standardization in substantially all incremental printers  
3       of a product line; said method comprising the steps of,  
4       for at least one chromatic colorant:

5                 storing, for access by each printer, a numerical rep-  
6       resentation of an absolute perceptual parameter for at  
7       least one tone; and

8                 later retrieving and applying the stored representa-  
9       tion to establish the printer dynamic range.

1       29. The method of claim 28, wherein:

2                 the tone is a maximum printable tone.

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1       30. The method of claim 29, wherein the storing step com-  
2       prises placing the numerical representation in at least  
3       one article selected from among:

4             each printer;  
5             a software cache accessible to each printer;  
6             a raster-image processor to be associated with each  
7        printer; and  
8             a software cache accessible to a raster-image proces-  
9        sor to be associated with each printer.

1       31. The method of claim 30, wherein the placing comprises  
2       memorizing the numerical representation in a device selec-  
3       ted from among:

4             a read-only memory; and  
5             an application-specific integrated circuit.

1       32. The method of claim 29, wherein:  
2             the storing step comprises placing the numerical rep-  
3       resentation in a printer driver used by each printer.

1       33. The method of claim 29, wherein the applying step  
2       comprises closed-loop control based upon:  
3             printing a test pattern that nominally includes the  
4       maximum tone; and  
5             measuring the test pattern with a calibrated sensor  
6       to derive a comparable absolute perceptual parameter for  
7       the nominally included maximum tone.

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1       34. The method of claim 33, wherein the closed-loop con-  
2       trol comprises:

3                 comparing the stored numerical representation of the  
4       perceptual parameter with the comparable measured percep-  
5       tual parameter; and

6                 from differences found in the comparison, deriving a  
7       correction function to be applied to image data in future  
8       printing.

1       35. The method of claim 34, wherein:

2                 the function comprises a correction, based on the  
3       retrieved at least one tone, that causes the printer per-  
4       ceptual output tones to be a linear function of input data  
5       level.

1       36. The method of claim 34, wherein:

2                 the storing step comprises storing numerical repre-  
3       sentations for plural tones;

4                 the retrieving step comprises retrieving the repre-  
5       sentations of the plural tones; and

6                 the function comprises a correction, based on the  
7       representations of the plural tones, that causes the prin-  
8       ter perceptual output tones to be a nonlinear function of  
9       input data level.

1       37. The method of claim 34, wherein the closed-loop con-  
2       trol comprises:

3                 in future printing, applying the correction function  
4       to image data.

1       38. The method of claim 29:

2               wherein the storing step comprises storing a numeri-  
3       cal representation of a standard value of the absolute  
4       perceptual parameter; and

5               further comprising the steps of:

6  
7               determining the absolute perceptual parameter  
8               for printers that represent worst-case  
9               performance within the product line, and

10  
11          selecting the numerical representation and se-  
12          lecting printer operating conditions in  
13          view of the determined parameter for said  
14          worst-case performance, to ensure that in  
15          each printer of the product line the apply-  
16          ing step will be able to force the dynamic  
17          range to encompass the standard value.